LAB #2: Tides, Datums and Echo sounding

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Introduction

This lab introduces students to more hydrography topics such as: tides, vertical datums, single beam echo sounders and Ellipsoidally Referenced Hydrographic Surveys. The lab requires that students research on topics pertaining to types of echo sounders, datums, height systems, sketching figures that are accurate to problems, and practice using tide tables.

Methodology and Results

Question 1

An echo sounder is a device that converts electrical energy to acoustic energy. The transducer focuses on bursting the energy in one direction or in a beam. This energy meets the seafloor which experiences reflection, transmission, and reflectance. The reflected energy is recorded by the echo sounder which records its data. Analogue echo sounders are the traditional modern echo sounders that record paper records while digital echo sounders are the more modern echo sounders record its data digitally [1].

Both echo sounders follow a cycle, analogue cycles start with generating an electric pulse which transmits the burst of energy in the water. After the echo is received and converted into electrical energy, the energy is amplified to be recorded. The data received contains measurements pertaining to depth in horizontal and vertical resolutions. This is the completion of the cycle which can begin again.

Digital echo sounders follow a similar cycle except when amplifying the returning energy, it is amplified as a function of time. Which is then converted to digital format through its depth measurements. However, the data can be displayed in several time varying formats.

Using a digital echo sounder is more advantageous than an analogue echo transmitter due to the various applications it can apply to the measurements. Digital echo sounders have the ability to digitalize its results in a system which easily allows for modifications such as receiving bandwidth and applying digital filters. For analogue echo sounders, this is a tedious process as it would have to apply several filters [2].

Another feature that digital has over analogue is its time varying format storage. The digital echo sounder can record epoch-based measurements which allows for real time processing of the data which improves accuracy. This is an option analogue cannot possess as its data representation is limited to the dimensions of the paper width it uses to record data.

Question 2

1. We can use simple trigonometry functions to solve for the resultant footprint. This is a figure of what it looks like:

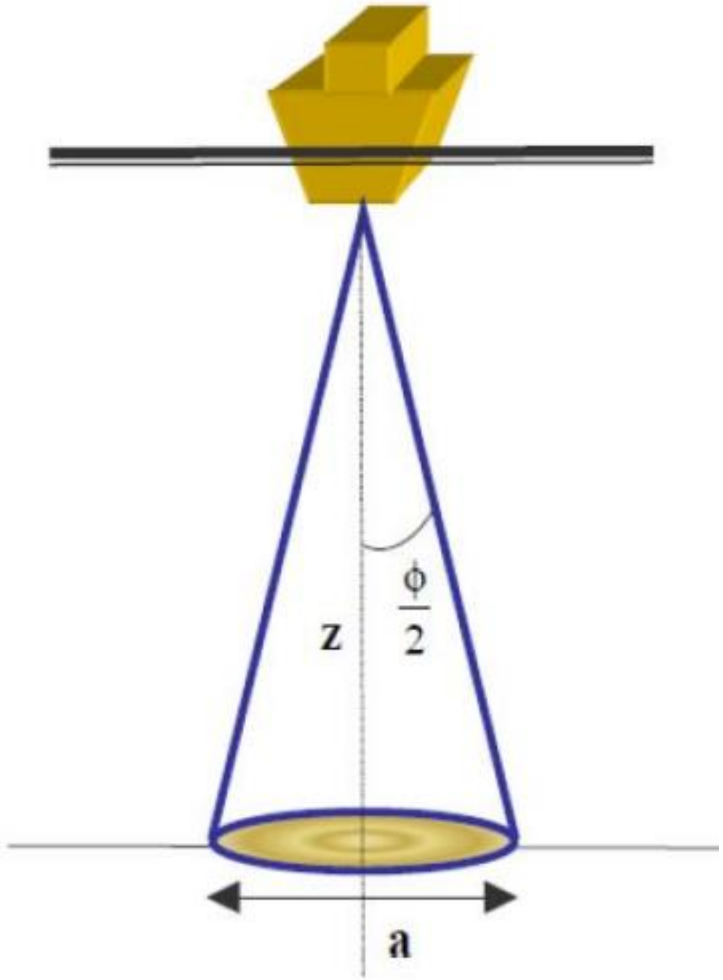


Figure 1: Figure of Echo Beam Sounder

In this figure, z = 36m, $\emptyset = 6.7°$. To solve for a:

$$2tan\left(\frac{\emptyset}{2}\right) = \frac{a}{z}$$

$$a = z2tan(\frac{\emptyset}{2})$$

$$a = (36)\ 2\tan\left(\frac{6.7}{2}\right)$$

$$a = 4.214m$$

The footprint size on the seafloor is $4.214m$.

2. Now, a measurement has been made against a seafloor at a slope illustrated as:

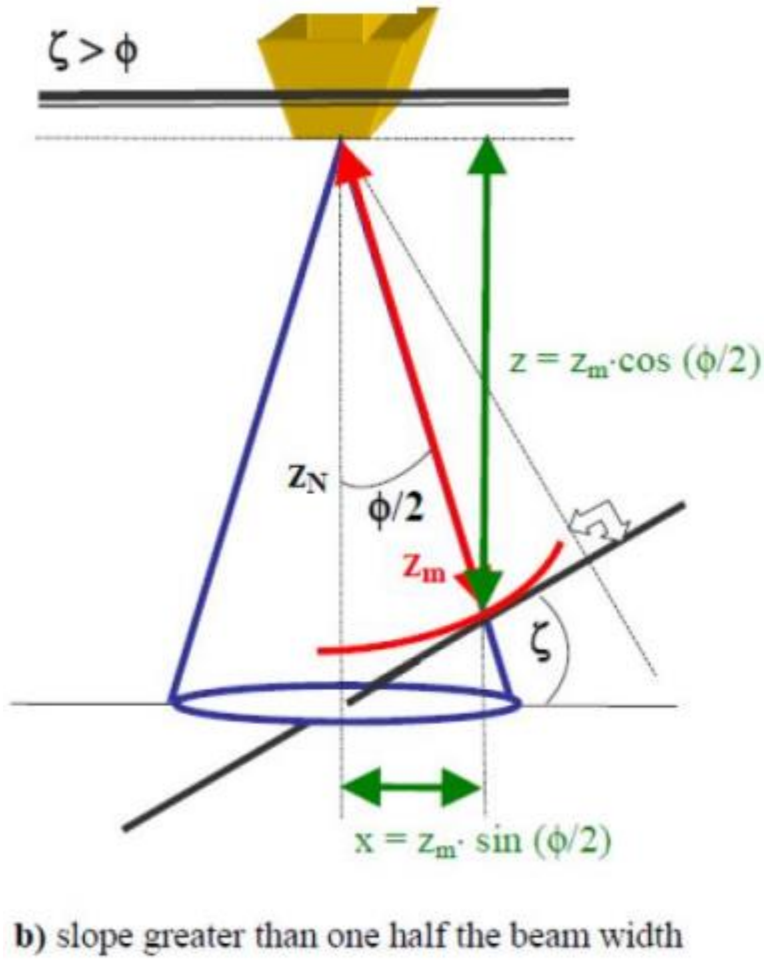


Figure 2: Slope of the Seabed > Width of Half of Beam

The slope of the seabed (10.2 degrees) is greater than half of the beam width (6.7/2 or 3.35 degrees). Therefore, we will use $(\frac{\emptyset}{2})$ rather than the slope of the seabed.

$$z = 48\cos\left(\frac{6.7}{2}\right) = 47.91m$$

$$x = 48\sin\left(\frac{6.7}{2}\right) = 2.80m$$

These measurements shift the area that encompasses the footprint. The echo can experience a reflectance, transmission, and absorption when meeting with the seabed.

Question 3

For this question, we will be referencing to the tide tables provided by [Reference 4]. Hooper Island, Md. Is a North American location so we will be looking at the *2017 East Coast of North and South America Including Greenland* tide table. On slide 361 of the PDF (out of 451), I found the index number (2025) for Hooper Island, its time correction for high and low water, and its height differences from Baltimore:

				on Baltimore, p.108						
2025	Middle Hooper Island	38° 17.8'	76° 12.3'	−4 40	−4 39	*1.32	*1.50	1.51	1.71	1.09

Figure 3: Index Number of Hooper Island

Going to page 108 of the PDF (slide 128) to find the Baltimore page I found its height associated with its epoch for February 14, 2017:

14 Tu	0317	- 0.1	- 3
	0851	0.9	27
	1519	- 0.2	- 6
	2122	1.0	30

Figure 4: Height Associated to Epoch

We will convert these Baltimore heights according to the Hooper Island corrections mentioned in [Figure 4]. We can tell the difference in high and low water by the numerical sign of the height (positive or negative):

Table 1: Time and Heights for Tide Water in Hooper Island on Feb 14, 2017

Baltimore		Differences		Hooper Island	
Time (hh mm)	Height (ft)	Time Corr.	Height Corr.	Approx. Time	Approx. Height
3 17	-0.1	-4.39	x1.50	22 38	-0.15
8 51	0.9	-4.40	x1.32	4 11	1.188
15 19	-0.2	-4.39	x1.50	10 40	-0.3
21 22	1.0	-4.40	x1.32	16 42	1.32

We will now compute for: range of tide, duration, and time since nearest tide, and use those values to find the correction to the height of a tide at any time.

Let's start with the former. Our time is 9:35 am, our range that includes this time is 4:11am to 10:40am:

$$Height\ Range\ of\ Tide\colon\ -0.3\ ft - 1.188\ ft = 1.488\ ft\ (has\ to\ be\ positive)$$

The time difference between those 2 epochs:

$$Duration: 10h\ 40m - \ 4h\ 11m = 6h\ 29m$$

The time since the nearest tide for 9:35am would be 10:40am:

$$Time\ from\ Nearest\ Tide: 10h\ 40m - 9h\ 35m = 1h\ 5m$$

To find the correction to the height we will look at Table 3 of the PDF (slide 391) and match our findings to find the correction to apply to our chart depth of 13.7 ft.

TABLE 3.—HEIGHT OF TIDE AT ANY TIME

Duration of rise or fall, see footnote	Time from the nearest high water or low water														
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
4 10	0 08	0 16	0 24	0 32	0 40	0 48	0 56	1 04	1 12	1 20	1 28	1 36	1 44	1 52	2 00
4 20	0 09	0 17	0 26	0 35	0 43	0 52	1 01	1 09	1 18	1 27	1 35	1 44	1 53	2 01	2 10
4 40	0 09	0 19	0 28	0 37	0 47	0 56	1 05	1 15	1 24	1 33	1 43	1 52	2 01	2 11	2 20
5 00	0 10	0 20	0 30	0 40	0 50	1 00	1 10	1 20	1 30	1 40	1 50	2 00	2 10	2 20	2 30
5 20	0 11	0 21	0 32	0 43	0 53	1 04	1 15	1 25	1 36	1 47	1 57	2 08	2 19	2 29	2 40
5 40	0 11	0 23	0 34	0 45	0 57	1 08	1 19	1 31	1 42	1 53	2 05	2 16	2 27	2 39	2 50
6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	2 00	2 12	2 24	2 36	2 48	3 00
6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19	2 32	2 45	2 57	3 10
6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	2 13	2 27	2 40	2 53	3 07	3 20
7 00	0 14	0 28	0 42	0 56	1 10	1 24	1 38	1 52	2 06	2 20	2 34	2 48	3 02	3 16	3 30
7 20	0 15	0 29	0 44	0 59	1 13	1 28	1 43	1 57	2 12	2 27	2 41	2 56	3 11	3 25	3 40
7 40	0 15	0 31	0 46	1 01	1 17	1 32	1 47	2 03	2 18	2 33	2 49	3 04	3 19	3 35	3 50
8 00	0 16	0 32	0 48	1 04	1 20	1 36	1 52	2 08	2 24	2 40	2 56	3 12	3 28	3 44	4 00
8 20	0 17	0 33	0 50	1 07	1 23	1 40	1 57	2 13	2 30	2 47	3 03	3 20	3 37	3 53	4 10
8 40	0 17	0 35	0 52	1 09	1 27	1 44	2 01	2 19	2 36	2 53	3 11	3 28	3 45	4 03	4 20
9 00	0 18	0 36	0 54	1 12	1 30	1 48	2 06	2 24	2 42	3 00	3 18	3 36	3 54	4 12	4 30
9 20	0 19	0 37	0 56	1 15	1 33	1 52	2 11	2 29	2 48	3 07	3 25	3 44	4 03	4 21	4 40
9 40	0 19	0 39	0 58	1 17	1 37	1 56	2 15	2 35	2 54	3 13	3 33	3 52	4 11	4 31	4 50
10 00	0 20	0 40	1 00	1 20	1 40	2 00	2 20	2 40	3 00	3 20	3 40	4 00	4 20	4 40	5 00
10 20	0 21	0 41	1 02	1 23	1 43	2 04	2 25	2 45	3 06	3 27	3 47	4 08	4 29	4 49	5 10
10 40	0 21	0 43	1 04	1 25	1 47	2 08	2 29	2 51	3 12	3 33	3 55	4 16	4 37	4 59	5 20
	Correction to height														
Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
1.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5
1.5	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.8
2.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
2.5	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.2

Figure 5: Correction to Height

After matching the parameters we computed for, the correction (see red boxes) is 0.1 ft. Applying this to the chart depth gives us a height of 13.8 ft for the height of the water level at 9:35am on Feb 14, 2017 at Hooper Island, Md.

Question 4

1. The vertical datum used for the Great Lakes is called the International Great Lakes Datum [3]. It is updated every 30 years to adjust its elevation of points due to effects of glacial isostatic adjustment. The

first vertical datum was called the International Great Lakes Datum of 1955 (IGLD (1955)) and was updated 30 years later (IGLD (1985)). Another update will be coming soon in 2025 [5].

The IGLD is related to the U.S Lake Survey (USLS) due to both being interested in geodetic surveying of their lands. With both providing surveys of their respective lands, they decided to combine their efforts to provide better surveys through: bench marks between datums, providing better references for GPS-derived orthometric heights and heights of water-level surfaces, and providing updated information [6].

The first IGLD was planned in 1953 (to develop the IGLD (1955)) to establish a basis for development of data dealing with the aspects of management of the Great Lakes [7]. The US and Canadian governments worked together to provide the necessary resources to perform this work. The IGLD was integrated in the common international datum in the US and Canada (North American Vertical Datum 1988). This unification reduced the effort in developing an updated IGLD (1985).

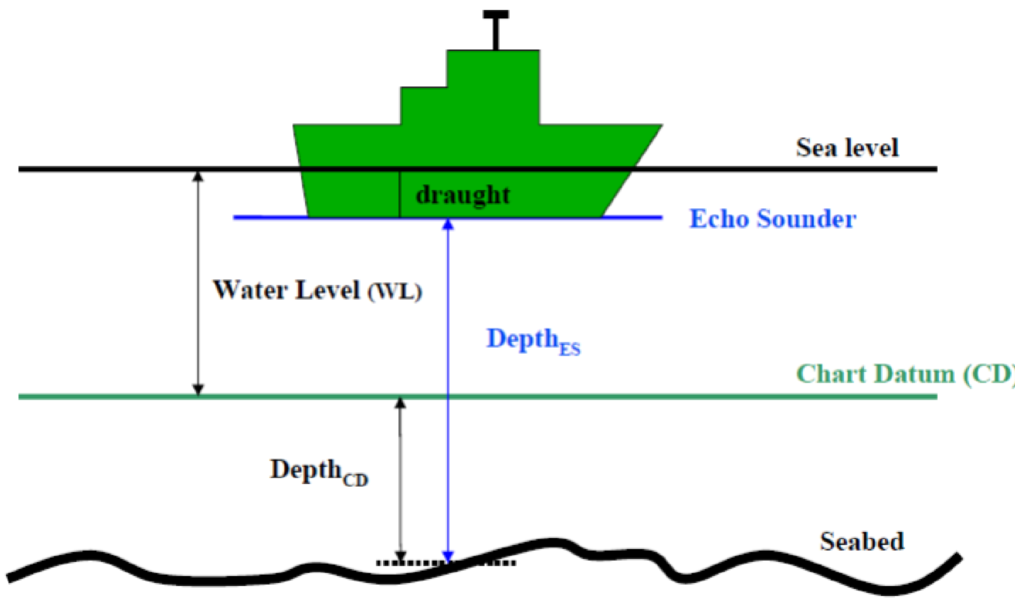
The update from 1955 and 1985 provided elevation changes in the water level which required adjustments with bench mark elevations. It also expanded its geodetic network and elevations referenced by the NGVD 1929 will be referenced to the NGVD 1988 version. Canada and the US were responsible for updating their own water levels for flooding insurance or zoning restrictions.

2. The height system used for the Great Lakes is a dynamic height system determined by GNSS technology [8]. Although dynamic and orthometric are different types of heights, the dynamic height system is used to derive the geopotential values of the lakes and can be used to find the difference between the values and the reference geoid. The height system uses physical geodesy methods such as airborne gravity data to derive orthometric heights of locations across Earth.

Question 5

We will be recreating a figure given our parameters and we will be using this equation to determine the reduced depth:

Water level data for Seabed Mapping



$$\text{Depth}_{CD} = \text{Depth}_{ES} + \text{draught} - \text{WL}_{CD}$$

Figure 6: Reduced Depth Formula + Figure

Table 2: Values for Parameters

h	Ellipsoidal height of the GPS antenna	45m
ZA	Offset between GPS antenna and vessel's reference point	10m
D	Observed depth (corrected for errors and heave)	40m
DD	Dynamic Draught	2m
ZT	Transducer offset	1m
SEP	Separation	56m

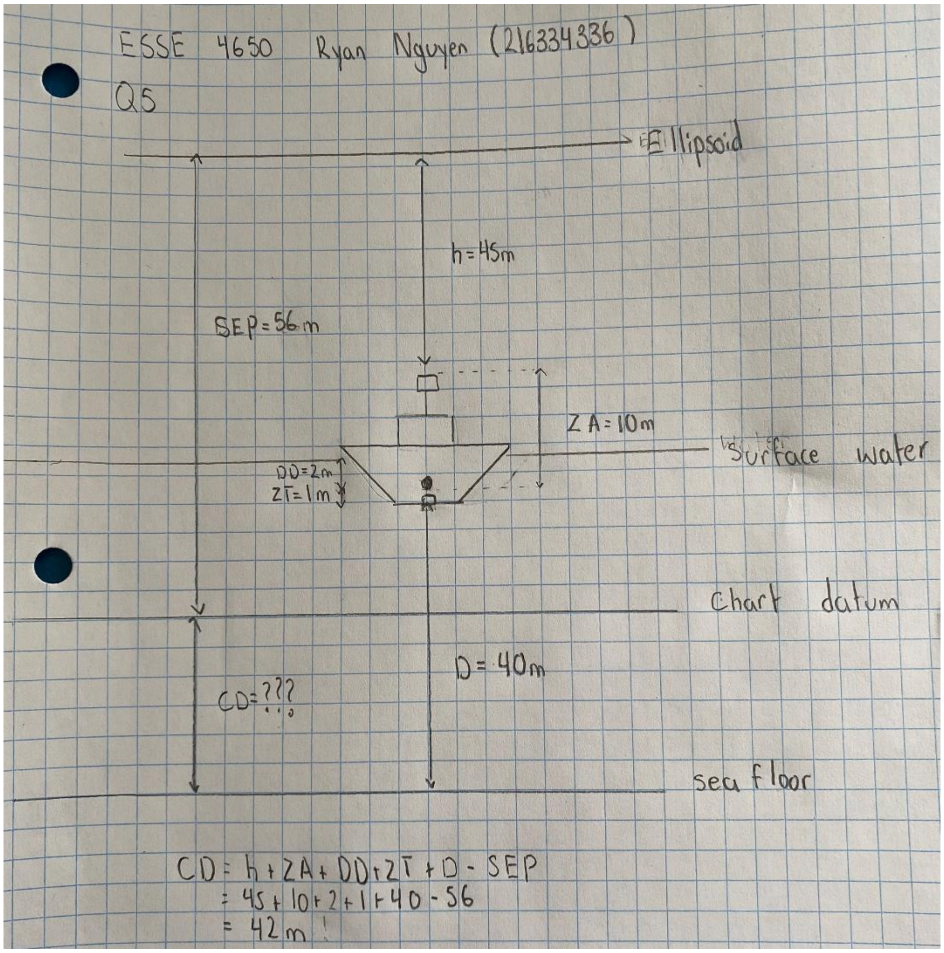


Figure 7: Diagram

The reduced depth is 42m.

<u>Resources</u>

Armenakis, C. (2022). Lecture: TIDES AND CURRENTS (Water Level and Flow). ESSE 4650 Hydrography. Toronto, Ontario, Canada: York University

[1] International Hydrographic Organization. (2005). Manual on Hydrography. pg 148-152. Retrieved January 29, 2022, from https://acls-aatc.ca/wp-content/uploads/2017/06/iho-manual.pdf

[2] Mizuno, K. (n.d.). The Latest in Digital Echo Sounders. Retrieved January 29, 2022, from https://www.koden-electronics.co.jp/eng/topics/pdf/the_latest_in_digital_echo_sounders.pdf

[3] International Great Lakes Datum update. (n.d.). Retrieved January 29, 2022, from http://www.greatlakescc.org/wp36/home-2/international-great-lakes-datum-update/#:~:text=The%20first%20such%20vertical%20datum,since%20the%20last%20ice%20age.

[4] National Current Observation Program (NCOP) - NOAA tides & currents. Tides & Currents. (n.d.). Retrieved January 28, 2022, from https://tidesandcurrents.noaa.gov/historic_tide_tables.html

[5] International Great Lakes Datum update. (n.d.). Retrieved January 29, 2022, from http://www.greatlakescc.org/wp36/home-2/international-great-lakes-datum-update/#:~:text=The%20first%20such%20vertical%20datum,since%20the%20last%20ice%20age.

[6] Zilkoski, D. B. (n.d.). North American Vertical Datum and International Great Lakes Datum: They Are Now One and the Same. Retrieved January 29, 2022, from https://www.ngs.noaa.gov/web/about_ngs/history/Zilkoski4.pdf

[7] IGLD 1985 Brochure on the International Great Lakes Datum 1985. (1992, January). Retrieved January 29, 2022, from https://www.lre.usace.army.mil/Portals/69/docs/GreatLakesInfo/docs/IGLD/BrochureOnTheInternationalGreatLakesDatum1985.pdf

[8] Roman, D., & Li, X. (n.d.). Heights in the Great Lakes Region Developed from GNSS and a Gravity Field Model (Paper 8407). Retrieved January 29, 2022, from https://geodesy.noaa.gov/web/science_edu/presentations_archive/files/cgu_poster.pdf